ENHANCING LOCATION-AWARE ROUTING IN VEHICULAR AD-HOC NETWORK WITH ARTIFICIAL INTELLIGENCE

SHORT SYNOPSIS

Submitted in partial fulfillment of the requirement of the degree of

DOCTOR OF PHILOSOPHY

To

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(Deemed to be University)

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Certificate

I hereby declare that the short synopsis on "Enhancing Location-Aware Routing in Vehicular Ad-Hoc Network with Artificial Intelligence" being submitted in partial fulfillment of the requirement for the degree of Doctor of Philosophy in the Department of Computer Science & Engineering under School of Engineering & Technology of Manav Rachna International Institute of Research & Studies, Faridabad during the academic year 2024-25. It is a bona fide record of original work carried out under the supervision of Dr. Shobha Tyagi, Dr. S. S. Tyagi and Dr. Prashant Dixit and has not been submitted in full or part to any other university or institute for degree or diploma. Further, it is certified that the Short Synopsis is plagiarism free and the proof has been submitted.

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Abstract

Vehicular Ad-hoc Networks (VANETs) are mobile ad-hoc networks involving vehicles and roadside units that organize by themselves. Vehicles communicate among themselves through variable wireless links. Since moving vehicles use IEEE 802.11 p, which is designed for vehicular environments, they have a transmission range of up to 1000 meters. This results in rapid changes in the routing path, which further results in the failure or delay in data delivery up to the destination node. Many routing protocols, such as Ad Hoc On-Demand Distance Vector (AODV) and Dynamic Source Routing (DSR), have been proposed in the past, which kept on enhancing the reliability of Vehicular Ad-hoc Networks. Directional Location aided Routing Protocol (DLRP) is one of such routing protocols. These reactive routing protocols outperform other methods by reducing the number of hops involved on the way. Though this method is very effective in enhancing the range of the sending node, quick next-hop discovery is yet a challenging task.

In this research, integrating Artificial Intelligence (AI) with the Directional Location-aided Routing (DLAR) protocol will enhance Location-Aware Routing in Vehicular Ad Hoc Networks (VANETs). This approach will improve efficiency, adaptability, and reliability in dynamic, high-mobility environments by enhancing the next-hop discovery process for more effective routing.

Keywords: Ad-hoc Network, Artificial Intelligence, Directional Location aided Routing Protocol (DLRP), Vehicular Ad-hoc Network (VANET).

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1. Description of Broad Area

Vehicular Ad-hoc Networks (VANET) are wireless networks constituted among moving vehicles on the road. It helps them share valuable information among the vehicles, which is helpful for society in one way or the other. The shared information can be used for entertainment purposes as well as for passing critical information to ensure the safety of people on the road. Minimum latency in communication between Vehicle to Vehicles (V2V) as well as Vehicle to Infrastructure units (V2I), hassle-free traffic flow, and safety on the road are of concern in the future Transportation Systems.

Vehicles involved in VANET have a peculiar feature that they tend to move on a fixed road map and the direction of motion is predictable. Also, being smart vehicles, they know their GPS locations. As shown in figure 1, provisions and the facilities may be based on topology, position, cluster, geo-cast and broadcast related to connectivity are generally meant to understand various types of routing protocols. All these techniques hold some or the other pros and cons related to performance. Proposed research aims to understand the existing routing protocols meant for VANET in terms of challenges, limitations and accordingly propose some enhancement to improve the performance.

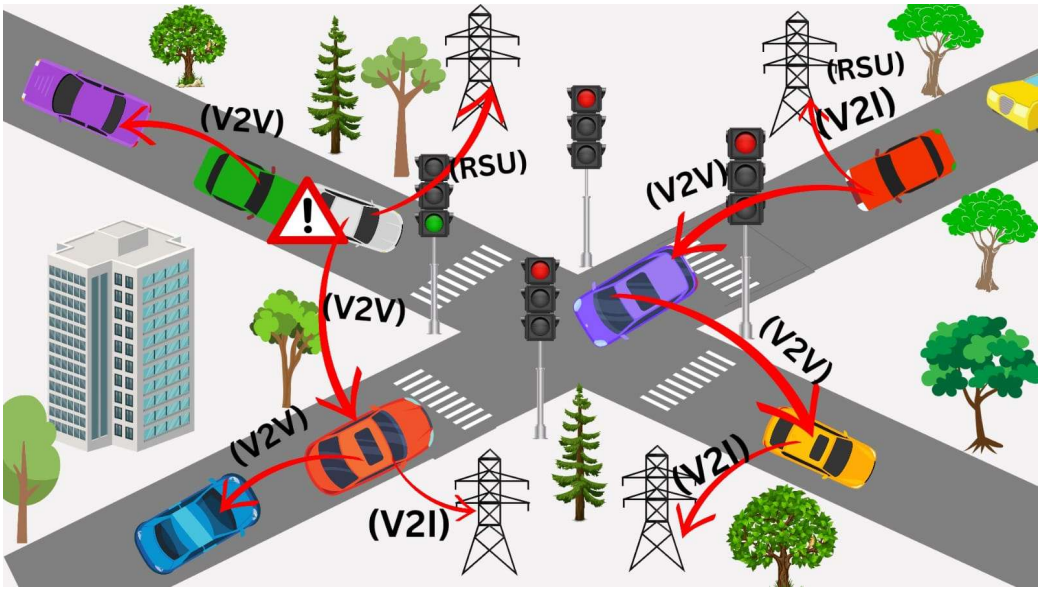

Figure 1. A typical Vehicular Ad-hoc Network (VANET) (Source: Self)

As time and technology evolved, various techniques were developed which when incorporated with the routing protocols in ad-hoc networks, enhanced routing in one or the other way. In present scenario, Artificial intelligence is one of such technology that

is helping in all aspects of life. It learns from past experience and improves upon to take suitable decisions in future. VANET is also not untouched by it. Sufficient number of literatures have revealed its efficiency in making efficient decision in selecting the next hop to transmit an information from one node to the other.

Various artificial intelligence techniques that can be used to position-based routing protocols for usage in vehicular ad hoc networks are being studied in this study. There are numerous nodes that can be chosen for the next hop in the direction of the goal using an appropriate AI technique. Available literatures have used some of the artificial intelligence techniques in mobile ad-hoc network. Therefore, applying them to vehicular ad-hoc network cannot be ruled out.

As the era of self-driven smart vehicles is evolving, this research will enhance the capabilities of self-driven vehicles by improving the critical data dissemination between them.

1.1 Ad-hoc Networks

Ad-hoc networks are temporary infrastructure less self-organizing networks that form spontaneously when devices tend to communicate with each other. Mostly they are wireless and have no base station or access point. As can be seen in figure 2, all devices coordinate in transferring the data from one node to the other using some or the other agreed-upon routing algorithm.

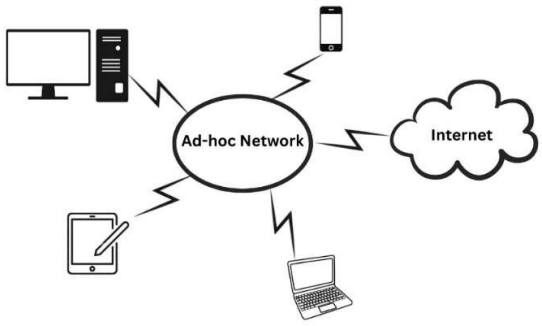

Figure 2. A typical ad-hoc network (Source: Self)

1.1.1 Classification of Ad-hoc Network

An ad-hoc network is of the following commonly used types, depending upon its application:

a) Mobile Ad-hoc Networks (MANETS): These are wireless networks involving mobile devices that configure and organize themselves.
b) Wireless Sensor Networks (WSN): These are the networks that are formed to collect information from the collection of sensor nodes on the fly.
c) Vehicular Ad-hoc Networks (VANETs): These wireless networks are created between the moving vehicles and other roadside infrastructures.
d) Flying Ad-hoc Networks (FANETs): Represent a new class of ad-hoc networks specifically designed for communication among drones.

The list of ad-hoc network classifications goes far beyond this, but their applications are very limited.

1.1.2 Vehicular Ad-hoc Network (VANET)

It's a decentralized network where vehicles dynamically connect and exchange data without the need for a fixed base station. Due to its fast-moving nature and frequently changing scenario, data delivery failure is a significant problem. The ongoing research is focused on efficient data delivery in an efficient and reliable manner. Various routing protocols are being explored for their reliability and efficiency for future smart vehicles.

1.1.3 Characteristics of VANET

To proceed with the research on VANET, its inherent to know its peculiar characteristics such as:

High Mobility:

High speed of vehicles makes the network very dynamic. Vehicles are added and leave the network at a fast speed, making the routing extremely difficult task.

Dynamic network topology:

High mobility of vehicles results in a continuously changing position and distance between two vehicles. Thus, topology goes on changing very rapidly.

Variable network size:

Size of VANET depends on the range of vehicle and density of vehicle. A VANET can be very large in size in city area and it can be very small on remote highways.

Frequent information exchange:

VANET keeps on exchanging information from rapidly passing by vehicle or road side unit.

Time Critical:

Data needs to be transmitted very quickly in order to avoid data loss if a node leaves the network during data transfer.

1.1.4 Components

a) **On-Board Units (OBUs)**: They act as the brains of a vehicle, managing communication with other vehicles and processing data for various functions.

b) **Roadside Units (RSUs)**: Fixed infrastructure units placed along roads to facilitate communication between the OBUs and connect to larger networks.

1.1.5 Communication Types

a) **Vehicle-to-Vehicle (V2V)**: Direct communication between vehicles for sharing information such as traffic conditions, accidents, or road hazards.

b) **Vehicle-to-Infrastructure (V2I)**: V2I communication facilitates data exchange between vehicles and roadside infrastructure elements, enabling the provision of traffic management, payment processing, and other intelligent transportation system (ITS) services.

c) **Vehicle-to-Everything (V2X)**: A broader scope involving all communications including pedestrians, cyclists, and other transport modes.

1.2 Routing protocols in VANETs

They are crucial for the effective transmission of data across a highly dynamic network of vehicles. These protocols need to account for the existing characteristics of VANETs, related to high mobility, frequent changes in topology, changing network densities, and urban vs. rural road scenarios. An overview of some key VANET routing protocols are presented below:

1.2.1 Topology-driven Routing:

These protocols make routing decisions based on the network's connectivity map, encompassing proactive and reactive strategies.

Proactive (Table-Driven) Systems:

a) **Optimized Link State Routing (OLSR):** Maintains updated routes to all nodes through periodic exchange of control messages. It's efficient in terms of finding routes quickly but can be bandwidth-consuming due to constant updates.

b) **Destination Sequenced Distance Vector (DSDV):** An enhancement of traditional distance vector protocols, it uses sequence numbers to ensure loop-free routes. It periodically updates routing tables, which can cause high overhead.

Reactive (On-Demand) Systems:

a) **Ad-hoc On-Demand Distance Vector (AODV):** It routes data based on demand generation, minimizing overhead caused by network changes. It uses RREQ and RREP messages for route discovery.

b) **Dynamic Source Routing (DSR):** It is utilized where the complete route to the destination is included in packet headers. It's efficient for networks with low to moderate mobility.

1.2.2 Geographical (Position-based) Routing Protocols

It use the geographical position of nodes to make decisions for routing, which is very useful in the highly dynamic VANET environment.

a) **Greedy Perimeter Stateless Routing (GPSR):** Uses the nodes' positions to forward packets in a greedy manner. If greedy forwarding isn't possible (due to a void), it switches to perimeter routing.

b) **Geographic Source Routing (GSR):** Combines geographic routing with source routing. It uses digital maps for routing around obstacles and is well-suited for urban environments.

1.2.3 Cluster-based Routing Protocols

In this method, nodes are grouped based on certain criteria, called clusters. These clusters choose a cluster head, which are responsible for inter-cluster routing.

a) **Cluster-based Location Routing (CBLR):** Clusters are formed based on the location of nodes, and routing is done cluster-to-cluster. This reduces routing overhead and enhances scalability.

1.2.4 Broadcast Routing Protocols

VANETs' high mobility and dynamic topology make broadcast routing useful for spreading information like traffic updates and safety alerts.

a) **Urban Multi-Hop Broadcast (UMB):** This protocol helps to prevent network congestion in urban areas by limiting unnecessary message broadcasts, forwarding messages only to the most distant relevant node.

b) **Distributed Vehicular Broadcast (DV-CAST):** Divides nodes into categories based on their position and uses different strategies for message dissemination in normal and intersection scenarios.

1.2.5 Hybrid Routing Protocols

These merge the characteristics of both proactive as well as reactive routing protocols.

a) **Zone Routing Protocol (ZRP):** Combines proactive routing within a local neighbourhood (a "zone") and reactive routing for communication between zones. This hybrid approach reduces control overhead in comparison to purely proactive protocols.

1.2.6 Overlay Routing Protocols

These protocols create an overlay network on top of the physical network to simplify routing.

a) **Vehicle-Assisted Data Delivery (VADD):** VADD improves data delivery efficiency by utilizing vehicles as temporary data carriers, ensuring data is always moving toward its final destination.

1.2.7 Challenges in VANET Routing

a) **High Mobility and Frequent Topology Changes:** Routing protocols must quickly adapt to the rapid changes in network topology.

b) **Scalability:** Given the large number of vehicles in urban environments, protocols must be designed to manage a high volume of nodes efficiently.

c) **Quality of Service (QoS):** Ensuring timely delivery of packets is crucial for safety applications.

d) **Security and Privacy:** Protecting data integrity and user privacy while ensuring secure communication.

VANET routing protocols are specifically tailored to the demands of vehicular networks, achieving a balance between efficiency, scalability, and reliability to enable a variety of applications, including safety features and infotainment services.

1.3 Role of Artificial Intelligence in VANETs

AI is revolutionizing various fields, including VANETs, where its applications hold significant promise. AI can significantly enhance VANET routing by addressing the inherent challenges associated with the high mobility and dynamic nature of vehicular networks. A detailed look at the use of AI in VANET routing is presented below:

1.3.1 Machine Learning (ML) in Routing Decisions

Predictive Routing:

a) **Traffic Prediction:** Machine learning models can forecast traffic flow and conditions using historical data, helping to optimize route selection.

b) **Mobility Patterns:** By analyzing vehicle movement patterns, machine learning algorithms can predict future positions of nodes, aiding in more reliable route maintenance and reduction of route discovery time.

Adaptive Routing:

a) **Reinforcement Learning:** This type of machine learning can be used to dynamically adjust routing strategies based on network conditions. For instance, Q-learning algorithms can learn and adapt to the best routing paths over time.

b) **Neural Networks:** Deep learning models, such as Deep Q-Networks (DQN), can help in making complex routing decisions by processing high-dimensional data from the network.

1.3.2 Fuzzy Logic in Routing

Decision Making:

a) **Traffic Uncertainty:** Fuzzy logic can handle the uncertainty and imprecision associated with traffic conditions and vehicle movements. It can be used to make decisions on packet forwarding by evaluating various factors such as distance to the destination, traffic density, and road conditions.

b) **QoS Adaptation:** Prioritizing routes based on Quality of Service (QoS) requirements while optimizing for latency, bandwidth, and reliability is possible with fuzzy logic systems.

1.3.3 Swarm Intelligence

Nature-inspired Algorithms:

a) **Ant Colony Optimization (ACO):** ACO, mimicking ant behavior, can identify the shortest paths in VANETs. Virtual pheromones help in selecting the best routes based on the collective learning of multiple nodes.

b) **Particle Swarm Optimization (PSO):** This algorithm, modeled after the social behavior of birds or fish, can be used to dynamically optimize routing paths by adjusting the routes based on collective knowledge and learning of the swarm.

1.3.4 Genetic Algorithms

Evolutionary Routing:

a) **Optimal Path Finding:** Genetic algorithms can be employed to find optimal or near-optimal routing paths by iteratively evolving candidate solutions. They use operators such as selection, crossover, and mutation to explore the solution space.

b) **Adaptation and Optimization:** By constantly modifying the routing strategies, these algorithms can adjust to shifting network conditions and provide reliable solutions in extremely dynamic contexts.

1.3.5 Neural Networks in Traffic Management

Real-time Decision Making:

a) **Deep Learning Models:** By analyzing massive datasets from network sensors, Convolutional Neural Networks (CNNs) and Recurrent Neural Networks (RNNs) can anticipate traffic congestion, allowing for dynamic route optimization in real-time.

b) **Vehicle Classification:** Neural networks can classify vehicles based on movement patterns, helping to optimize routes for different types of vehicles (e.g., emergency services, public transport).

1.3.6 Benefits of AI in VANET Routing

a) **Enhanced Predictability:** AI can improve the predictability of routing decisions by leveraging historical data and real-time analytics.

b) **Adaptability:** Communication networks can become more durable and resilient as a result of AI-driven routing algorithms' ability to dynamically adjust to shifting network conditions.

c) **Efficiency:** Machine learning algorithms can optimize routing paths, reducing latency and improving the overall efficiency of data transmission.

d) **Scalability:** AI techniques can handle large-scale network environments, making VANETs more scalable across urban and rural settings.

e) **Energy Efficiency:** AI can optimize the use of energy resources by selecting routes that minimize power consumption.

1.3.7 Challenges and Considerations

a) **Computational Overhead:** Implementing AI algorithms requires significant computational resources, which can be challenging for real-time applications.

b) **Data Privacy and Security:** AI in VANETs necessitates robust data privacy and security measures

c) **Integration:** Integrating AI with existing communication frameworks and protocols requires careful planning and standardization.

AI significantly enhances VANET routing through various advanced methodologies, improving efficiency, reliability, and adaptability. While there are challenges to

consider, the potential benefits make AI a promising field for advancing vehicular communication networks.

2. Literature review

The objective of this literature review is to give a thorough understanding of the state of VANET routing protocols and AI integration, to highlight the potential advantages of utilizing AI to enhance routing in VANETs, and to identify important research gaps. In other words, this review thoroughly examines the various approaches, algorithms, and technological frameworks that support VANET routing protocols. By scrutinizing the myriad approaches and solutions employed within VANETs to facilitate efficient data transmission, seamless connectivity, and reliable communication among vehicles, the nuances, challenges and opportunities inherent in fusing AI with routing mechanisms within vehicular networks can be unveiled. This synthesis enables a nuanced understanding of how AI can drive advancements in routing efficiency, reliability, and scalability, paving the way for improved traffic management, enhanced network performance, and ultimately, a more robust and adaptive VANET ecosystem.

G. P. K. Marwah et al. [1] in their research have introduced a method that combines ensemble machine learning with a hybrid metaheuristic algorithm, effectively addressing the crucial issue of network stability in VANETs. The hybrid optimization method utilizing Seagull Optimization and Artificial Fish Swarm Optimization, demonstrates significant improvements in key performance indicators. Notably, throughput experiences a substantial increase, while data transmission delay and energy consumption are noticeably reduced. The ensemble machine learning technique integrates Support Vector Machines, Naive Bayes, Artificial Neural Networks, and Decision Trees, enabling accurate forecasting of VANET mobility and effective routing strategies. Their integrated approach represented a significant advancement in VANET research, promising enhanced reliability and efficiency in vehicular communication networks.

H. Gao, C. Liu et al. [2] in their research paper proposed a routing system that addresses challenges in unstable wireless communication by introducing a VANET routing system based on the Manhattan mobility model. Their model incorporated roadside units (RSUs) for data transmission and optimization in both wireless and wired modes. The paper considers the complexities of moving vehicles and network connectivity issues by utilizing road networks and vehicle node movement patterns. Their proposed greedy algorithm optimizes vehicular communication, and to enhance performance, a

wired RSU network is integrated. Routing decisions are analyzed through a probabilistic model, confirming connectivity between vehicles and RSUs for various transmission ranges. Comprehensive experiments demonstrate that this approach improves real-time network transmission performance, as indicated by metrics such as package delivery ratio, time delay, and number of hops, surpassing the performance of standard protocols.

In order to address issues with effective data transmission in vehicular ad hoc networks (VANETs), K. Kandali et al. [3] developed a novel clustering-based routing protocol that combines a modified K-Means method with Continuous Hopfield Network and Maximum Stable Set Problem, or KMRP. An improved K-Means algorithm is used by KMRP. In addition, the cluster number and initial cluster heads are found using the Maximum Stable Set Problem and the Continuous Hopfield Network. The Link Reliability Model is used to assign vehicles to clusters, taking the place of the K-Means distance parameter. The selection of Cluster-head utilizes a weight function considering speed, free buffer space and degree of nodes. The results demonstrate KMRP outperforms previous schemes in highway vehicular environments, reducing traffic congestion, increasing throughput, decreasing transmission delay, and ensuring cluster stability in high density and mobility, leading to improved Packet Delivery Ratio.

R. A. Nazib et al. [4] investigated the application of Reinforcement Learning (RL) algorithms to improve routing efficiency in vehicular ad-hoc networks (VANETs). By enabling communication between vehicles, VANETs offer the benefits of road safety, traffic management, and in-vehicle entertainment. High speeds and poor connection, on the other hand, are frequent causes of traffic interference. Efficient communication requires routing, and RL algorithms, a type of artificial intelligence, are thought to be helpful for optimizing memory and processing resources. RL-based algorithms like Q-learning-based Adaptive Geographic Routing (QAGR), Intersection-based V2X routing using Q-learning (IV2XQ) and Context-aware Edge-based Packet Forwarding approach (CEPF) are important because routing in VANETs is crucial for passenger safety. There is currently a dearth of thorough study on RL-based routing protocols for VANETs, despite this seemingly promising capacity to optimize parameters. In order to close this gap, this evaluation compares these systems' features, advantages,

drawbacks, and uses in addition to highlighting unresolved concerns and prospective research directions that should guide the advancement of RL-based VANET routing protocols in the future.

A. Mchergui et al. [5] in their article explored recent advancements in intelligent solutions for traffic safety, convenience, and efficiency, driven by developments in communication, computer technology, and intelligent transportation systems. Artificial Intelligence (AI) plays a crucial role in this landscape, augmenting traditional methods that are based on data. Diverse data sources are utilized for purposes such as route planning, enhancing driver awareness, predicting mobility to prevent hazards, and improving passenger comfort and safety in Vehicular Ad-hoc Networks. The article offered a comprehensive overview of AI techniques currently under exploration in VANET research projects, assessing their strengths and weaknesses in the VANET environment. It concludes by identifying potential research opportunities in the VANET domain to fully harness the capabilities of AI.

S. R. Valayapalayam Kittusamy et al. [6] in their paper introduces a novel algorithm to enhance mobility management in Vehicular Ad-hoc Networks (VANETs) using Road Side Units (RSUs). The adaptive weighted clustering protocol (AWCP) forms arbitrary node clusters, from which a head (CH) is selected using optimized parameters through Enhanced Whale Optimization Algorithm (EWOA). This approach aims to improve the VANET system's mobility management, eliminating the need for costly RSUs. For a reliable clustering model, the motion of each vehicle is studied by using a vehicular mobility routing protocol, that considers its speed as well as position. The suggested AWCP-EWOA model outperforms the AWCP as well as AWCP-Whale Algorithm (WA) protocols in terms of clustering efficiency and mobility augmentation.

R. Chandren Muniyandi et al. [7] in their study addressed the challenge of adapting Mobile Ad-hoc Network (MANET) protocols, particularly proactive Optimized Link State Routing (OLSR), for use in Vehicular Ad-hoc Networks (VANETs). VANETs, designed for vehicles in urban or highway environments, rely on routing protocols for information exchange. OLSR, while initially created for MANET, faces challenges in VANET due to the need for a remodeled routing table encompassing all potential paths. To enhance OLSR's performance in VANET and meet Quality of Service (QoS) requirements, the study introduces an Improved Harmony Search Optimization (EHSO)

method. This algorithm takes into account OLSR parameters and incorporates two selection methods namely Roulette Wheel Selection, and Tournament Selection, to enhance memory. Empirical investigation illustrates that the proposed methodology effectively satisfies Quality of Service (QoS) criteria and outperforms existing algorithms in VANET scenarios.

In their study, S. Jiang et al. [8] discussed difficulties with Q-learning-based spatial routing techniques for Vehicular Ad-hoc Networks (VANETs). These challenges include the Q-value table's dynamic nature leading to slow convergence and inefficient resource use, as well as the potential inefficiency of global message forwarding when relying only on local information. The suggested method incorporates Q-learning and unmanned aerial vehicles (UAVs) with spatial routing to address these problems. During the aerial phase, the UAV employs fuzzy logic and a DFS algorithm to ascertain an all-encompassing routing path while considering road traffic circumstances. This path is then sent to the ground vehicle. The vehicle retains a fixed-size Q-table during the ground phase, which is optimized using a reward mechanism. depending on this table, it filters routing requests depending on the global routing path before forwarding them. The method shows notable gains in packet delivery and end-to-end latency, indicating that it can increase performance and efficiency in VANET settings. In dynamic vehicular networks, the adaptive UAV-assisted routing concept has potential for enhancing communication.

An overview of ad-hoc networks transient wireless communication networks made up of mobile nodes equipped with wireless transceivers was given by M. A. Al-Absi et al. [9] in their study. Nodes function as hosts and routers in Mobile Ad-hoc Networks (MANETs), enabling wireless communication. MANETs are subsets that are supported by different infrastructures, such as Flying Ad-hoc Networks (FANETs) and Vehicular Ad Hoc Networks (VANETs). Applications for ad-hoc networks may be found in emergency response, disaster relief, military activities, and sensor networks. This paper is unique in that it provides the first thorough overview, comparing and explaining common ad-hoc network types and emphasizing research-useful simulation techniques. It highlights the significance of routing protocols and offers scholarly works with citations for additional reading.

Y. Azzoug et al. [10] in their document thoroughly explored the history and future of Vehicular Ad-hoc Network (VANET) routing issues, encompassing both core routing tasks and various bio-inspired techniques. It outlines the evolution and trends in addressing VANET routing problems alongside the development of nature-inspired meta-heuristics. A newly suggested classification system organizes key VANET routing issues according to their characteristics, extent, and the kinds of metaheuristics employed for optimization. The paper anticipates upcoming routing challenges in VANETs and discusses how nature-inspired optimization algorithms address or can address these challenges. Each routing problem is accompanied by relevant related works, initially presenting conventional protocols before delving into bio-inspired protocols, showcasing the effectiveness of nature-inspired optimization techniques. This text serves as a comprehensive guide, furnishing an updated literature review and forward-thinking insights into emerging bio-inspired optimization methods and diverse combinations of metaheuristics tailored to address specific challenges in VANET routing.

M. Ren et al. [11] in their paper focused on the challenge of efficiently propagating information in Vehicular Ad-hoc Networks (VANETs), where vehicles are in constant motion. A system has been developed to group vehicles, facilitating the swift exchange of information. The paper explores various techniques for grouping vehicles, emphasizing considerations such as selecting a leader for each group, forming and maintaining the groups, and evaluating the overall system's performance. The goal is to ensure that information is disseminated quickly and reliably to all relevant parties in diverse situations within VANETs.

In their study, P. K. Shrivastava et al. [12] talked about how Vehicular Ad-hoc Networks (VANETs) are developing quickly within the larger context of Mobile Ad-hoc Networks (MANETs). Through vehicle-to-vehicle (V2V), vehicle-to-infrastructure (V2I), and hybrid communication, vehicles may communicate dynamically inside VANETs. Specialized issues beyond traditional MANET protocols arise from the dynamic and unpredictable nature of VANET communication, which is impacted by several factors including road conditions, network size, and the constant influx of new cars. This research does a thorough analysis of many VANET routing protocol classes, providing comprehensive recommendations in a single source. Using Network

Simulator 3 (NS-3), the study applies AODV, DSDV, and OLSR routing protocols to Vehicle-to-Vehicle (V2V) nodes and evaluates them according to Quality of Service (QoS) metrics such packet overhead, throughput, and packet loss ratio. Among AODV, OLSR, and DSDV, simulations using the IEEE 802.11p model show that AODV is the best routing technique inside the model.

V. K. Quy et al. [13] in their paper discussed the growing demand for improved transfer speeds in mobile systems, driven by the rapid increase in multimedia applications and services. Mobile Ad-hoc Networks (MANETs), developed in the 1970s, involve self-configuring mobile devices establishing parameters for data transmission independently of pre-installed infrastructure systems. MANETs have diverse applications in healthcare, military operations, smart agriculture, and disaster prevention. Derived from MANETs, vehicle ad-hoc networks are tailored to distinctive features of vehicular networks, characterized by specific movement patterns and high mobility facilitated by Road Side Units (RSUs). VANETs, like MANETs, are influenced by node mobility and communication technologies. The study aims to provide a comprehensive survey of recent communication solutions tailored for VANETs, categorizing them into three primary approaches: multi-metric strategies, integration with Unmanned Aerial Vehicles (UAVs), Cloud and Internet systems, and intelligent methodologies. The findings reveal a recurring framework in the design of VANET communication solutions, and each proposed solution is analyzed to highlight its core focus and achievements. Improving adaptive, dependable, and intelligent routing protocols for VANETs, particularly in smart urban environments, is identified as a significant challenge.

M. A. Hossain et al. [14] through their paper addressed the challenges in Cognitive Radio Vehicular Ad-hoc Networks (CR-VANETs), which integrate Cognitive Radio (CR) technology with VANETs to overcome spectrum scarcity. In this dynamic setting, establishing effective routes for data transmission is critical, given the swift movement of vehicles and challenges in channel accessibility. This document introduces an innovative routing algorithm, the 2-Hop Multi-Objective Harris Hawks Optimization algorithm, designed to prioritize a 2-hop route between source and destination vehicles. This approach enhances route stability and contributes to successful data transmission. Through simulations conducted with OMNeT++ and SUMO, the algorithm's efficacy

is showcased, revealing favorable outcomes in throughput, delay, packet loss rate, packet delivery ratio and communication overhead. The introduced algorithm tackles crucial challenges in CR-VANET routing, offering the potential for more dependable and efficient data transmission in dynamic vehicular networks.

In their study, P. Shah et al. [15] tackled the difficult problem of creating efficient routing protocols for vehicular ad hoc networks (VANETs), taking into account variables such erratic vehicle speeds, low power, and variable mobility patterns. VANETs are autonomous networks that link via the internet. They come with a range of obstacles, including multiple hop routing, bandwidth limitations, node mobility, large-scale networks, and device variation. Important topics covered in the article include entertainment, broadcasting, routing, security, and Quality of Service (QoS), especially in emergency scenarios. It conducts an in-depth analysis of wireless standards in VANETs, evaluating the efficiency and accuracy of routing protocols. The study introduces Swarm-Intelligence based routing protocols, emphasizing their unique features and performance metrics. A comparative analysis with established ad-hoc routing protocols demonstrates the effectiveness of this approach in enhancing overall network performance. The research contributes insights into the latest developments in routing protocols for VANETs, aiming for more effective and efficient communication in dynamic vehicular environments.

In their study, G. D. Singh et al. [16] discussed the difficulties with node administration, security, and routing in vehicular ad hoc networks (VANETs). The quick and dynamic mobility of VANETs presents challenges for traditional routing techniques. Although they have problems, swarm intelligence routing approaches like Particle Swarm Optimization (PSO) and Ant Colony Optimization (ACO) show potential. In response, scientists present the Hybrid Genetic Firefly Algorithm-based Routing Protocol (HGFA), which is intended to function in sparse as well as dense networks. The advantages of both the Firefly algorithm and Genetic Algorithm (GA) are combined in this hybrid technique. A comparative investigation shows that HGFA performs much better in communication efficiency than Firefly and PSO approaches in both cases. This groundbreaking approach might improve VANET routing, especially when different network densities are involved.

In their study, L. Luo et al. [17] discussed routing difficulties in vehicular ad hoc networks (VANETs), with a focus on the quickly expanding Internet of Vehicles (IoV). VANET routing protocols have problems with significant communication overhead, latency, and sporadic connection. Consider this approach as a V2X smart navigation system for cars. It's similar to having a perceptive driver that observes the state of the road in real time and learns from previous traffic patterns. This system is designed to make decisions at intersections, choosing the best routes based on what it has learned. It's like having a thoughtful friend who not only knows the history of traffic but also considers the current situation to guide you efficiently. Real-time monitoring models quickly assess network load, allowing timely adjustments in routing decisions to prevent congestion. Extensive simulations and comparisons with three benchmark methods show that the suggested algorithm performs better in important metrics like communication overhead, packet delivery ratio, and end-to-end delay. The research breakthrough holds promise for significantly improving routing efficiency in VANETs and advancing Internet of Vehicles technology.

F. Belamri et al. [18] in their paper concentrate on crafting dependable, scalable, and exceptionally efficient routing methods tailored for Vehicular Ad-hoc Networks (VANETs) within the domain of Intelligent Transportation Systems (ITS). The aim is to enhance the Quality of Service (QoS) in VANETs, crucial for facilitating communication between vehicles and empowering informed decision-making by drivers. Nevertheless, attaining a specific level of Quality of Service (QoS) presents a notable challenge given the distinctive attributes of VANETs, such as constrained mobility, elevated node speeds, and dynamic topology. The paper extensively elucidates QoS routing protocols found in literature, categorizing them into two groups based on optimization methodologies: QoS routing protocols that do not depend on meta-heuristics and those that utilize meta-heuristic approaches for optimization.

In their research, K. Afzal et al. [19] investigate how to construct the Internet of Vehicles (IoV) by integrating the Internet of Things (IoT) with Vehicular Ad-hoc Networks (VANETs). In order to decrease communication delays, lower the danger of collisions, improve message delivery, and lessen traffic congestion, VANETs are essential for permitting ad hoc communication among cars. One notable breakthrough is the integration of Unmanned Aerial Vehicles (UAVs) with VANETs. Efficient

routing protocols are essential for Vehicular Ad-hoc Networks (VANETs). For such networks to have successful communication, commonly used protocols are essential. This study suggests a strategy to improve overall performance and data delivery efficiency by integrating UAVs into the VANET paradigm. Simulation findings show how typical routing methods in vehicle-to-vehicle (V2V) communication settings compare with variations supported by UAVs. Up to 60% better performance is achieved by the drone-assisted DA-AODV protocol than conventional protocols, especially when more sinks are added. These results highlight how well the suggested approach works in VANETs to lower overhead, boost average throughput, and enhance packet delivery.

M. Vafaei et al. [20] in their paper addressed the challenge of maintaining Quality of Service (QoS) in Vehicular Ad-hoc Networks (VANETs). The proposed solution involves a multi-path transmission method that segments video packets into frames and transmits them through diverse paths, aiming to enhance the overall quality. However, the dynamic topology and intermittent connectivity of VANETs pose challenges to QoS maintenance. To tackle these hurdles and enhance the quality of service for entertainment and traffic safety applications in VANETs, their paper suggests a routing approach centered on adaptive junctions with support of quality of service. The proposed solution utilizes an Ant Colony Optimization algorithm to tackle the issue and integrated an algorithm based on fuzzy logic to choose the most suitable next-hop. The selection is based on metrics related to the vehicle's position, link quality, and mobility. Overall, the paper presents a comprehensive approach to address the unique challenges of QoS maintenance in VANETs, providing a foundation for improved performance in video streaming and other VANET applications.

Al-Ahwal et al. [21] in their paper discussed the role of routing protocols as standards that facilitate communication among different entities in a network, enabling efficient data transfer from source to destination. Their study focussed on evaluating the performance of two routing protocols: Ad-hoc On-demand Distance Vector (AODV) and Ad-hoc On-demand Multipath Distance Vector (AOMDV), using the Root Relative Squared Error (RRSE) as a key metric. They presented simulation results involving node counts ranging from 5 to 450. The findings revealed that AOMDV outperforms

AODV in terms of efficiency, robustness, and reliability in the first experiment. However, AODV showed better RRSE values in the second experiment.

G. Husnain et al. [22] in their research mentioned Vehicular Ad Hoc Networks (VANETs) play a crucial role in enabling various Intelligent Transportation System (ITS) technologies. However, increased traffic leads to dynamic changes in vehicular network topologies, and the sparse distribution of vehicles, particularly on highways, poses significant challenges for network scalability. This instability hampers the ability of vehicles in the network to maintain stable routes, further increasing network disruptions. To tackle these issues in IoT-based transportation networks, they presented a bio-inspired, cluster-based routing algorithm called the intelligent probability-based Whale Optimization Algorithm (p-WOA). This algorithm facilitates cluster formation in vehicular communications by considering key parameters such as communication range, node density, vehicle velocity, and highway routes, which are integrated into the algorithm's fitness function. The proposed p-WOA algorithm was compared against established methods like Ant Lion Optimizer (ALO) and Grey Wolf Optimization (GWO). Results indicated that p-WOA optimally determines the number of cluster heads (CH) and significantly improves performance metrics like Packet Delivery Ratio (PDR), average throughput, and latency. The findings demonstrate that VANETs utilizing ITS applications can enhance clustering efficiency by up to 75%, lowering communication costs, minimizing routing overhead, and increasing cluster lifespan.

M. ul Hassan et al. [23] In their research mentioned Vehicular Ad Hoc Network (VANET) as a complex wireless communication system designed to facilitate smooth data exchange among vehicles, combining both centralized and decentralized control mechanisms. According to them, this network leverages advanced 5G connectivity and specialized topological configurations to improve the transmission of data packets. Vehicles within the network communicate with one another and with roadside units (RSUs). However, high-speed conditions can lead to disruptions, with black hole attacks posing a significant threat. In such attacks, a malicious vehicle interferes with data packet forwarding, jeopardizing secure communication. To address these challenges, their study introduced an intelligent cluster-based routing protocol. The proposed system operates in two key phases: first, it utilizes an artificial neural network (ANN) model to identify malicious nodes, and second, it forms clusters using enhanced

clustering algorithms and assigns cluster heads (CH) for effective communication. The routing protocol employs a modified Ad Hoc On-Demand Distance Vector (AODV) protocol for efficient route discovery and optimal path selection, improving both request and reply processes. The effectiveness of this approach was evaluated using the BHT dataset, measuring performance indicators including accuracy, precision, recall, F1 score, and loss. Simulation results using NS-2.33 revealed an impressive 98.97% accuracy in detecting black hole attacks.

A. Ali et al. [24] mentioned Vehicular Ad-Hoc Networks (VANETs) face significant challenges due to their dynamic nature, which arises from the high speeds and sparse distribution of vehicles. This leads to issues such as network fragmentation and packet routing difficulties, complicating efforts to establish robust and scalable communication, particularly in congested scenarios. Clustering is often suggested as a solution to enhance scalability; however, existing clustering techniques frequently create too many clusters, which can waste limited wireless resources and increase communication overhead. This results in longer routing paths and higher latency, ultimately compromising protocol reliability. To tackle these challenges, they introduced a novel clustering algorithm called Harris Hawks Optimization-based Clustering for VANET (HHOCNET). This algorithm mimics the cooperative foraging techniques of hawks, specifically their surprise pounce strategy, to effectively create optimized vehicular clusters. Their results in MATLAB was compared against state-of-the-art algorithms like Gray Wolf Optimization-based Clustering (GWOCNET) and Multi-objective Particle Swarm Optimization (MOPSO) which showed that the HHOCNET algorithm reduces the number of selected cluster heads to 36.04%. This approach improved network performance by up to 15%, enhanced resource efficiency, and minimized end-to-end communication latency, thereby addressing the key issues in VANET clustering effectively.

K. Chandramohan et al. [25] mentioned in their research, neighbouring radio networks are characterized by the lack of immediate communication infrastructure after deployment, limited transmission ranges of radio transceivers, and a lack of awareness of potential neighbouring nodes. Furthermore, Vehicle-to-vehicle communication emerges as an effective method to share information through asymmetric vehicular ad hoc networks, offering high security and reduced energy consumption. They mentioned

the D-LAR (Directed Location Assist) protocol as a new energy-efficient solution designed to assess the energy levels of nodes within the network. It incorporated a sleep scheduling technique to manage the active and sleep states of nodes. Additionally, the D-LAR protocol offered improved accuracy in determining the location of moving vehicles compared to existing location support protocols. Simulation results indicated that the proposed D-LAR method significantly reduced the delay time for detecting collision attacks and enhances overall security, demonstrating its advantages over current systems.

Dutta et al. [26] in their comprehensive review explored recent advancements in VANETs, covering network architectures, communication protocols, and sensing technologies. they discussed the integration of Wireless Sensor Networks (WSNs) and Internet of Things (IoT) to support applications like traffic monitoring and safety alerts. The paper highlighted the use of Machine Learning (ML) in V2V communications for safety applications, such as collision avoidance, and in data forwarding for efficient routing. While it does not focus solely on D-LAR, it provides a broad perspective on AI's role in VANETs, including routing protocols. The review also addressed challenges like high mobility and latency, which are relevant to location-aided routing.

S. Bilal et al. [27] in their survey examined the integration of AI, IoT, and 5G/6G technologies in VANETs, analyzing their impact on applications like routing, mobility prediction, and safety. they discussed how AI techniques, such as ML and deep learning, can process data from multiple sources to optimize routing decisions, enhance driver awareness, and predict traffic patterns. The paper evaluated the merits and demerits of AI-based methodologies, emphasizing their potential to improve VANET performance when combined with high-speed 5G/6G networks. Future research prospects included developing lightweight AI models for real-time processing and addressing data privacy concerns.

F. Aktas et al. [28] in their paper explored the application of AI and machine learning techniques to routing in next-generation networks, such as 6G and satellite networks. They highlighted the limitations of traditional routing protocols in handling the complexities of these networks, including high data traffic and dynamic topologies. The study discussed the significance of AI in network optimization, focusing on cognitive intelligence, knowledge planes, and the role of Software-Defined Networking (SDN).

Challenges such as computational overhead and real-time processing were addressed, along with potential solutions like lightweight AI models. While not specific to VANETs, the principles of AI-enabled routing are applicable to directional location-aided protocols also.

M. ul Hasan et al. [29] in their research proposed an AI-driven routing protocol that utilises Artificial Neural Networks (ANN) to enhance the security of the Ad hoc On-Demand Distance Vector (AODV) protocol in VANETS. The protocol mitigates black hole attacks, where malicious nodes disrupt data forwarding, by using ANN to intelligently select secure routes based on network behavior analysis. The approach operates in two phases: ANN-based detection of malicious nodes and cluster-based routing with enhanced clustering algorithms. The protocol integrates 5G connectivity for high-speed data transmission and uses the BHT dataset for evaluation, achieving 98.97% accuracy in detecting black hole attacks. Simulation results using NS-2.33 demonstrate improved packet delivery ratios, reduced end-to-end delay, and better network throughput compared to standard AODV. The use of ANN for secure routing showcases AI's capability to process complex network data and make real-time decisions, which could be applied to D-LAR to enhance its next-hop selection process. For instance, ANN could predict the reliability of nodes within D-LAR's request zone, improving both security and efficiency. Although the protocol is based on AODV, its location-aware clustering approach aligns with D-LAR's reliance on positional data, making it a relevant reference for AI-driven directional routing.

A. Fatma et al. [30] in their comprehensive survey examined the application of AI, particularly deep learning, in routing for next-generation networks like 6G and satellite networks. Traditional routing algorithms struggle with the heterogeneity, dynamism, and time-variability of these networks, failing to meet end-to-end Quality of Service (QoS) and Quality of Experience (QoE) requirements. AI techniques address these challenges by analyzing network parameters such as delay, loss rate, and signal-to-noise ratio to identify congestion points, traffic bottlenecks, and spectrum availability. Although not focused on VANETs, the paper's insights into AI-driven routing for dynamic networks are highly applicable to VANETs, where vehicle mobility creates similar challenges. Deep learning could enhance D-LAR by predicting optimal paths within the request zone, reducing broadcast overhead. Reinforcement learning could

adapt D-LAR's parameters in real time based on traffic density, improving efficiency and reliability. The call for reproducible research suggests a need for practical AI implementations in VANETs, potentially extending to D-LAR.

B. Indraneel [31] in his paper investigates the integration of AI into traditional routing protocols like Border Gateway Protoco (BGP), Open Shortest Path First (OSPF), and Multiprotocol Label Switching (MPLS) to enhance network adaptability and decision-making. He focus on deep reinforcement learning for predictive traffic engineering, enabling networks to anticipate congestion, optimize routes dynamically, and mitigate failures proactively. The paper's emphasis on reinforcement learning for predictive routing is directly applicable to VANETs, where D-LAR relies on accurate positional data. Deep reinforcement learning could refine D-LAR's request zone by predicting vehicle trajectories, reducing unnecessary broadcasts. The focus on resilience aligns with VANETs' need for reliable communication in dynamic environments. Applying these AI techniques to D-LAR could enhance its performance in terms of latency and packet delivery ratio.

In view of the detailed literature review, key research findings are summarized in Table 1.

Table 1: Summary of Literature Review of VANET Routing and AI

Sr. No.	Author, Title, Year	Objective	Methodology Used	Conclusion & Future Scope
1	R. A. Nazib et al., "Reinforcement Learning-Based Routing Protocols for Vehicular Ad Hoc Networks: A Comparative Survey", 2021 [4]	Address the lack of comprehensive research on RL-based routing protocols for VANETs. Compare these systems in terms of design, benefits,	Investigate the application of RL algorithms to improve routing efficiency in VANETs. Evaluate and compare the performance of different RL-	RL algorithms show promising potential in optimizing routing parameters for VANETs. There is a need for further comprehensive research on RL-based routing

		problems, and applications. Identify open issues and research challenges to guide future development.	based routing protocols. Examine parameters such as bandwidth, delay, throughput, overhead, and packet-delivery ratio.	protocols for VANETs. Future studies should address design issues, benefits, problems, applications, and research challenges.
2	A. Mchergui et al., "Survey on Artificial Intelligence (AI) techniques for Vehicular Ad-hoc Networks (VANETs)", 2022. [5]	Identify and assess recent innovations in intelligent solutions that contribute to safer, more convenient, and efficient traffic management within VANETs.	Provide a comprehensive overview of AI techniques in VANET research projects. Assess the strengths and weaknesses of these AI techniques in the VANET environment.	Identify potential research opportunities to fully harness the capabilities of AI in the VANET domain.
3	S. R. Valayapalayam Kittusamy et al., "An enhanced whale optimization algorithm for vehicular communication networks", 2022. [6]	Introduce a novel algorithm to enhance mobility management in VANETs using Road Side Units (RSUs).	Develop adaptive weighted clustering protocol (AWCP) to form random node clusters.	The proposed AWCP-EWOA model improves clustering efficiency and mobility management, outperforming

			Select cluster heads by optimizing network parameters through the enhanced whale optimization algorithm (EWOA). Study vehicle motion using a vehicular mobility routing protocol that considers speed and position.	AWCP and AWCP-Whale Algorithm (WA) protocols. Other methods can also be incorporated for further performance enhancement.
4	G. D. Singh et al., "Hybrid Genetic Firefly Algorithm-Based Routing Protocol for VANETs", 2022. [16]	Address challenges in VANETs, focusing on node management, security, and routing. Discuss the limitations of traditional routing protocols in dynamic	Propose HGFA, a hybrid routing protocol for VANETs, combining Genetic Algorithms and Firefly algorithms to address limitations of traditional approaches. Its	HGFA demonstrates superior performance over Firefly and PSO in both sparse and dense network scenarios, improving communication efficiency. The research offers a promising solution for

		VANET environments. Evaluate the potential of swarm intelligence techniques like ACO and PSO.	performance will be compared with Firefly and PSO.	enhancing routing in VANETs, particularly in dynamic environments with varying network densities.
5	Al-Ahwal et al., "Performance Evaluation and Discrimination of AODV and AOMDV VANET Routing Protocols Based on RRSE Technique," 2023. [21]	Using the Root Relative Squared Error (RRSE) metric, this research aims to evaluate the performance of AODV and AOMDV routing protocols. The study further analyzes the impact of initial node energy and network size on their performance.	The study uses simulation to evaluate the performance of the routing protocols under different scenarios. This study employs the RRSE algorithm to compare AODV and AOMDV.	It provides a valuable comparative analysis of AODV and AOMDV, highlighting the strengths and weaknesses of each protocol under different conditions. However, there is room for further research to expand the scope of the study and explore the performance of these protocols in more complex and realistic network environments.
6	G. Husnain et al., "A Bio-Inspired Cluster Optimization Schema	To address challenge of unstable routing	It introduces a novel routing algorithm	It offers a promising solution to improve routing

	for Efficient Routing in Vehicular Ad Hoc Networks (VANETs)," 2023. [22]	in VANETs caused by dynamic traffic patterns and sparse vehicle distribution. Propose a bio-inspired, cluster-based routing algorithm (p-WOA) to enhance network stability and efficiency. Demonstrate the superiority of p-WOA over existing algorithms like ALO and GWO.	called p-WOA, inspired by whale optimization. The algorithm's performance is evaluated through simulations, considering factors such as communication range, vehicle density, speed, and route. The results are then compared against established algorithms (ALO and GWO).	stability in VANETs. The proposed p-WOA algorithm demonstrates superior performance compared to existing algorithms. However, further research is needed to fully evaluate its effectiveness in real-world settings and to address potential limitations.
7	A. Ali et al., "Harris Hawks Optimization-Based Clustering Algorithm for Vehicular Ad-Hoc Networks," 2023. [24]	The goal is to develop an algorithm that identifies the ideal number of clusters for a given vehicular environment to optimize network performance.	Utilizing hawk hunting strategies, the Harris Hawks Optimization (HHO) algorithm is employed to efficiently solve the multi-objective	To optimize clustering in VANETs utilizing nature-inspired algorithm. The HHOCNET algorithm reduces cluster size and improves network efficiency.

			clustering problem.	

The literature survey highly suggests the need for deeper exploration into emerging contemporary artificial intelligence methodologies with VANET routing strategies. By doing so, VANETs could potentially see significant improvements by minimize routing overhead, reduce hop count, and decrease packet delivery delay. This integration will present a viable solution to address the dynamic challenges inherent in vehicular environments. Further refinement and investigation into this fusion are essential to fully realize its benefits, advancing VANETs towards more robust and adaptive communication systems.

3. Research Gaps

AI provides a flexible, adaptive, and intelligent method for routing in VANETs, outperforming traditional techniques in handling the dynamic and unpredictable characteristics of vehicular networks. These methods adapt to rapidly changing VANET topologies and proactively adjust routes to maintain connectivity amid frequent changes. After an extensive and detailed literature review of the inevitable role of Artificial Intelligence (AI) into Vehicular Ad hoc Networks following research gaps are observed:

i. Traditional VANET routing methods make binary decisions, leading to suboptimal choices in uncertain conditions. Artificial Intelligence (AI) can enhance decision-making by incorporating imprecise factors like signal strength and vehicle speed.
ii. Reinforcement Learning (RL) enables routing protocols to learn and improve over time through interaction with the environment. Therefore, VANET routing algorithms can also learn to further improve routing actions for successful packet delivery.
iii. Traditional VANET routing protocols struggle with large networks due to increased computational complexity. Artificial Intelligence-based algorithms can efficiently manage large-scale VANET complexities.
iv. AI can integrate varied data sources such as GPS and real-time traffic data. This holistic approach can improve routing accuracy compared to traditional methods that rely on limited information.

Thus, AI can provide a flexible, adaptive, and intelligent method for routing in VANETs, outperforming traditional techniques in handling the dynamic and unpredictable characteristics of vehicular networks.

4. Problem Statement

Despite the inherent complexity and dynamic nature of vehicular ad hoc networks (VANETs), traditional routing protocols struggle to maintain efficient and reliable network connectivity due to their reliance on static rules and limited adaptability. This results in frequent route failures, increased latency, and suboptimal decision-making under uncertainty. There is a pressing need to develop an adaptive routing framework that leverages artificial intelligence techniques, such as machine learning and reinforcement learning, to effectively manage the dynamic topology of VANETs. This framework should incorporate diverse data sources and enable proactive route optimization to enhance overall network performance, scalability, and responsiveness to changing conditions.

Integrating artificial intelligence (AI) techniques into vehicular ad hoc network (VANET) routing protocols can significantly enhance communication efficiency and reliability in vehicular environments' dynamic and fluctuating conditions. VANETs facilitate vehicle-to-vehicle (V2V) and vehicle-to-infrastructure (V2I) communication, crucial for intelligent transportation systems but challenged by high vehicle mobility, changing network topologies, and variable traffic densities.

Imbibing artificial intelligence into routing mechanisms may effectively address the challenges of adaptive and intelligent decision-making by predicting traffic congestion and suggesting optimal routes, reducing latency and packet loss, thereby ensuring reliable communication. It can also refine routing strategies based on past experiences, allowing the network to adapt to changes such as varying speeds, road closures, and weather conditions, thus enhancing the performance of location-aware routing in VANETs.

5. Research Objectives

Because of the limitations of prominent routing protocols, vehicular ad-hoc networks may further be weaved upon with the following research objectives as:

1. To perform rigorous survey of the routing methods in Vehicular Ad-hoc Networks (VANETs) and explore the adaptability and routing-related horizons of Artificial Intelligence in VANET routing protocols.
2. To propose an AI-based routing framework for VANETS to further minimise the routing overhead, reduce hop count, and decrease packet delivery delay in VANETs, compared to the existing routing methods.
3. To design and implement a routing framework for VANETs that utilizes artificial intelligence techniques, specifically machine learning and reinforcement learning, to adapt to dynamic network conditions effectively.
4. To conduct performance evaluations of the proposed AI-based routing framework to assess its scalability and effectiveness in large-scale VANET scenarios compared to traditional routing protocols.

6. Research Methodology

This research on enhancing location-aware routing in VANETs with AI follows a three-step methodology as illustrated in Figure 3. First step involves selecting a suitable Artificial Intelligence model based on research objectives and integrating it into the VANET routing system. In second step, the simulation environment is set up using sumo and NS2 to evaluate the system's performance depending upon varying vehicular densities, speeds, and communication conditions. Performance metrics such as packet delivery ratio and end-to-end delay are measured to evaluate the system's effectiveness. In final step, evaluation of AI-enhanced routing system's performance is done and compared with traditional routing approaches.

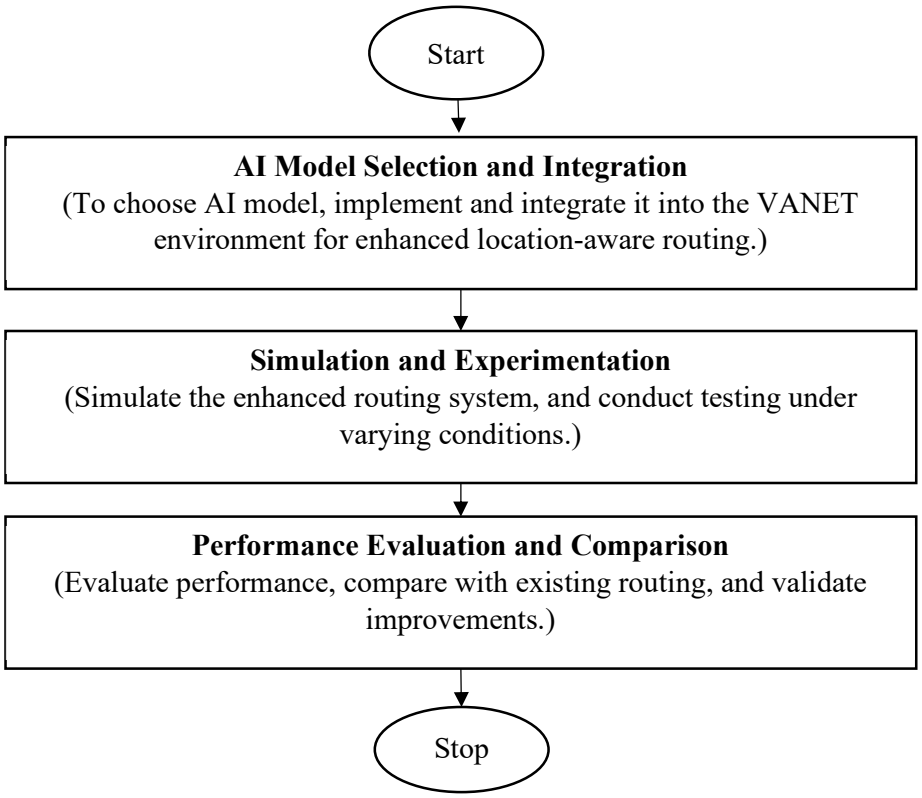
Start
AI Model Selection and Integration
(To choose AI model, implement and integrate it into the VANET environment for enhanced location-aware routing.)
Simulation and Experimentation
(Simulate the enhanced routing system, and conduct testing under varying conditions.)
Performance Evaluation and Comparison
(Evaluate performance, compare with existing routing, and validate improvements.)
Stop

Figure 3. Flow chart representing research methodology (Source: Self)

7. Expected Outcome of the Research

The proposed research aims to improve the directional location-aided routing protocol for vehicular ad-hoc networks (VANETs). While prior research has explored various enhancement methods, there's limited integration of Artificial Intelligence (AI) techniques specifically for VANETs. Despite AI's success in routing for other types of ad-hoc networks, its application to VANETs remains underexplored. This research expects to fill this gap by leveraging AI to minimize routing overhead, reduce hop count, and decrease packet delivery delay in VANETs.

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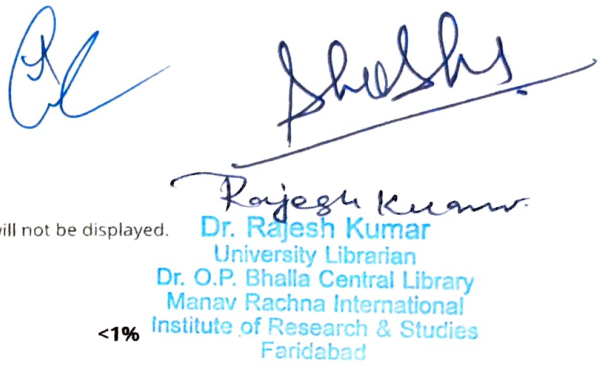

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ENHANCING LOCATION-AWARE ROUTING IN VEHICULAR AD-HOC NETWORK WITH ARTIFICIAL INTELLIGENCE

SHORT SYNOPSIS

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20/Ph.D./050

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Abstract

Vehicular Ad-hoc Networks (VANETs) are mobile ad-hoc networks involving vehicles and roadside units that organize by themselves. Vehicles communicate among themselves through variable wireless links. Since moving vehicles use IEEE 802.11 p, which is designed for vehicular environments, they have a transmission range of up to 1000 meters. This results in rapid changes in the routing path, which further results in the failure or delay in data delivery up to the destination node. Many

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